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### SPECIAL FUELS FOR HIGH-SPEED DIESEL ENGINES

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The increased use of engines operating on heavy fuels has led to perfecting these engines and adapting them to high speeds because the price of fuel is lower, the engine is more sturdy, and the thermal yield is more advantageous from the economic point of view.

The tendency of the fuel to ignite is measured with a CFR engine modified for diesel operation and compared with standard fuels, which were at first blends of cetene ( $C_{16}H_{32}$ , n-hexadecene), with a very brief period of delay and methyl naphthalene ( $C_{11}H_{10}$ ), an aromatic hydrocarbon with a very great delaying effect. Since cetene is an unsaturated hydrocarbon, it is unstable and forms peroxides. For this reason, it has been replaced by cetane ( $C_{16}H_{34}$ ), the corresponding paraffinic hydrocarbon, which is more stable and has a great tendency for self-ignition. The cetane rating is the percentage of cetane in a mixture of cetane and  $\alpha$ -methyl naphthalene which gives the same performance in a motor as the fuel under test.

The cetane rating is determined by different methods and using special engines. The behavior of the fuels in diesel engines can be evaluated with the help of the diesel index, which is calculated from the following formula:

$$\text{Diesel Index} = \frac{\text{Aniline point } ^\circ F \times \text{density } A P}{100}$$

The diesel index is a function of the chemical structure of the fuel. The index is higher when the fuel contains a larger amount of paraffinic hydrocarbons. The approximate relation between the diesel index and the cetane rating is: cetane rating = .8 diesel index + 10.

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Straight-chain hydrocarbons have a more pronounced tendency toward self-ignition than aromatic hydrocarbons and heavy hydrocarbons more than light hydrocarbons. In diesel fuels, the cetane rating increases with the ignition temperature of the fuel up to a certain value, after which the cetane rating decreases.

The tendency of a fuel to ignite spontaneously also depends on the construction of the cylinder chamber. The delay in firing is relatively less as the pressure and temperature become greater.

The vaporization and the proper mixing of the fuel with air depend on the viscosity and also the injection pressure and turbulence, which are determined by the design of the injector and of the combustion chamber. Very high viscosity of the fuel hinders its fine vaporization, and the particles, if they are too large, do not have time to burn completely during the explosion cycle and will be deposited on the cylinder walls and the piston, where they will form carbon or will foul the injector. Large diesel units use special preheaters for high-viscosity fuels, but small engines do not have these attachments. A fuel which has too low a viscosity will not seal or lubricate the pump. Moreover, since the vaporized particles are too small, they do not have a high speed in the heated air.

The efficiency of a motor increases with the increased cetane rating of the fuel, but only up to a certain point, after which a higher cetane rating does not improve performance. The cetane rating which gives maximum performance for each type of diesel motor has been determined.

Paraffinic fuels have a high cetane rating but also a high congelation temperature and so cannot be used in cold weather. Even at temperatures above the congelation point, crystals of paraffin are formed which clog the filter and interrupt the feeding of the motor. Asphaltic fuels have a desirable congelation point, but a low cetane rating because of their aromatic structure. Without over-evaluating the importance of a very high cetane rating, it appears evident that for high-speed motors, the fuel must have a short ignition lag, because then a complete and rapid combustion is assured. In addition, the fuel must have a congelation point low enough to permit operation at low temperatures. By mixing paraffinic motor fuels with the asphaltic motor fuels which we produce, we obtain fuels which meet the conditions in Rumania.

Refining motor fuels with an aqueous solution of alkaline hypochlorite at 50-100°C raises the cetane rating about seven points. The hypochlorite solution oxidizes the mercaptans without lowering the total sulfur content of the fuels. A low mercaptan content in fuels improves their quality.

For marine and aircraft diesels, which require fuels with a high cetane rating and a low congelation point, experiments are being conducted with additives which lower the congelation point or improve the combustible qualities as well as with synthetic fuels, which are expensive. The experiments give great promise of perfecting fuels for high-speed diesel engines. The effect of these additives in decreasing the ignition lag is greater for fuels with low cetane ratings than for those with high ratings. Some of the requirements put to these additives are that they improve the combustible quality, that they have no deleterious qualities, and that they be very stable and cheap. Experiments have been conducted using acetyl peroxide, tetrahydronaphthalene, methyl nitrate, propyl nitrate, butyl nitrate, nitrobenzene, etc.

Experiments will be conducted with Rumanian synthetic products in order to improve the congelation point of paraffinic fuels. One disadvantage of these additives is their corrosive action during combustion in the motor.

Another problem which has arisen from the increased use of high-speed marine and aircraft diesel engines, and one which must be solved, is the improvement in the starting quality of the fuels. Starting is very difficult in very cold weather and special heaters or fuel are necessary.

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Some of the additives which were used experimentally to improve cold starting are n-heptane, ethyl ether, 2,2-dinitropropane, acetyl thiophene, amyl nitrate, carbon disulfide, etc.

Some interesting conclusions can be drawn from the tests which have been made. For fuels without special additives, an increase of ten points in the cetane rating lowers the starting temperature approximately 7°C. The addition of volatile compounds improves starting at low temperatures if these additives also have a good combustibility. None of the substances used improved starting at low temperatures unless it was used in a concentration of at least 10%, although the cetane rating determined by the CFR engine showed an appreciable improvement. Naturally, there are some substances which do not influence the cetane rating, but do improve the starting quality of the fuel.

The high-speed diesel engine is being used more and more because of the following advantages that it has over the gasoline engine: cheap fuel, more economic thermic efficiency, and less danger of fire. Even when special fuels must be used, the diesel engine is more economical than the gasoline engine.

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